

REMARKS

The specification was amended to correct the informalities regarding the units of measure that were objected to by the examiner. Claims 1-2, 8, 13, 18-21, 28-33, 35, 40, 43, and 45 have been amended and claims 3, 9, 36-39, and 46 have been canceled. Claims 1-2, 4-8, 10-35, and 40-45 are pending in this application.

In the Office Action of June 21, 2005, the drawings were objected to under 37 C.F.R. § 1.83(a) for not including a stinger pipe as claimed in claim 9. Claim 9 was canceled, so the drawings do not require amendment.

Claims 1, 13, 19-21, 28, 29, 31, and 38 were objected to because of various informalities. Claim 1 was amended such that the subparts of the claim begin with lowercase letters and the word “and” was added between the final subpart and the subpart preceding the final subpart. Claims 13, 19, 20-21, 29, and 31 were amended to change the words “further comprising” to “wherein”. Claim 28 was amended to conform the units of measure to the proper form. These amendments were made to remove informalities, not to address any issues directed to the merits of the patentability of the subject matter of the invention.

Claims 1-46 were rejected under 35 U.S.C. § 112 as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claims 1-2, 8, 18-21, 29-30, 32-33, 35, 40, 43, and 45 were amended and claims 3, 9, 36-39, and 46 were canceled. Applicants respectfully traverse this rejection based on the claims as currently amended.

Claim 1 was amended to “a combination” instead of “the combination” since there was no antecedent basis for using “the”. Claims 2 and 43 were amended to clarify the structural limitation being recited in the claims. Claim 3 was canceled in response to the examiner’s rejection. Claim 8 was amended to clarify the structural limitation recited by the claim and to remove the ambiguity relative to “a support” and “a/said support” as set forth in claims 6 and 7. Claim 9 was canceled in response to the examiner’s rejection. Claim 18 was amended to remove the trademark/trade names of Hastelloy and Inconel. Claim 19 was amended to clarify the structural limitation recited by the claim that the membrane support is located between the membrane and the catalyst. Claim 20 was amended to clarify the structural limitation recited by the claim. Claim 21 was amended

to remove the structural limitation that was the subject of the examiner's rejection. Claims 29 and 30 were amended to clarify the structural limitation recited by the claims. Claims 32 and 33 were amended to be more specific concerning the meaning of high pressure. Claim 35 was amended to remove the term considered vague and indefinite by the examiner. Claims 36-39 were canceled in response to the examiner's rejection. Claim 45 was amended to clarify the structural limitation recited by the claim and to correct the antecedent basis. Claim 46 was canceled in response to the examiner's rejection.

Claims 1-8, 10-15, 17, 19-21, 25, 29, 30, 36-43 and 45 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Minet et al. (U.S. 5,229,102) in view of Mikus et al. (WO 99/18392). Applicants respectfully traverse this rejection based on the claims as currently amended.

Minet et al. discloses an apparatus for steam reforming of a hydrocarbon to produce H_2 , CO and CO_2 that uses a ceramic membrane to separate the hydrogen from the other streams. Mikus et al. discloses a flameless combustor process heater that has an oxidation reaction chamber with an inlet for oxidant and outlet for combustion products and a fuel conduit capable of transporting a fuel mixture to a plurality of fuel nozzles within the oxidation reaction chamber. The temperature of the combined mixture of oxidant and fuel is greater than the autoignition temperature of the combined mixture resulting in flameless combustion.

There is no suggestion to combine these two processes to produce the apparatus of the present invention, because Mikus et al. teaches that the use of a flameless combustor process heater in a steam reformer results in higher average temperatures. (Mikus et al., p. 17 lines 24-25). The membranes of the present invention do not operate well under the higher temperatures provided by the flameless combustor process heater in a steam reforming reactor as disclosed by Mikus et al., so it would not have been obvious for one of ordinary skill in the art to combine these two references to obtain the present invention.

There are two reasons that the membranes do not function effectively under the higher temperatures taught by Mikus et al. First, the membranes comprising palladium, platinum, nickel, silver, yttrium, cerium, holmium, lanthanum, gold and alloys thereof

undergo intermetallic diffusion at higher temperatures that results in decreased permeability, and second, the membranes comprising tantalum, vanadium, and niobium experience lower permeability at higher temperatures.

The membranes comprising metals from the first group that includes palladium, platinum, nickel, silver, yttrium, cerium, holmium, lanthanum, and gold cannot function at the higher average temperatures between “800 °C and 870 °C” as disclosed in Mikus et al. (p. 17, lines 12-13) because of the intermetallic diffusion that occurs. For example, the present application discloses that the maximum operating temperature of the palladium membranes is 550 °C. (p. 28, lines 18-19). In addition, Exhibit A to this response provides more clarification on the decreased permeability of the membranes at temperatures greater than 550 °C. This article, published in Vol. 44, No. 2 of the AIChE Journal, shows the drop in hydrogen flux across palladium membranes and provides graphs showing the deterioration in the hydrogen permeation rate at temperatures greater than 550 °C. (p. 318). The determination of the temperature at which intermetallic diffusion occurs is based on the Tamman temperature of the metal as discussed in Exhibit A. The range of Tamman temperatures of the first group of metals shows that membranes comprising these metals will experience intermetallic diffusion at temperatures less than the temperatures provided by the flameless combustor process heater as taught by Mikus et al., and thus it would not have been obvious for a person of ordinary skill to substitute the flameless combustor process heater as taught by Mikus et al. for the heater used in the steam reforming reactor disclosed by Minet et al.

Tamman temperatures are calculated based on the melting points of each metal, and these melting points were obtained from the CRC Handbook of Chemistry and Physics, 71st Edition. Palladium has a melting point of 1554 °C and a Tamman temperature of 640 °C; platinum has a melting point of 1772 °C and a Tamman temperature of 750 °C; nickel has a melting point of 1453 °C and a Tamman temperature of 590 °C; silver has a melting point of 962 °C and a Tamman temperature of 345 °C; yttrium has a melting point of 1522 °C and a Tamman temperature of 625 °C; cerium has a melting point of 798 °C and a Tamman temperature of 263 °C; holmium has a melting point of 1470 °C and a Tamman temperature of 599 °C; lanthanum has a melting point of 918 °C and a Tamman temperature of 323 °C; and gold has a melting point of 1064 °C

and a Tamman temperature of 396 °C. These melting points and Tamman temperatures were rounded to the nearest degree.

Tantalum, vanadium and niobium do not have low Tamman temperatures, but the decreased permeability to hydrogen of membranes comprising tantalum, vanadium and niobium at higher temperatures is shown in an article titled Hydrogen Transport through Tubular Membranes of Palladium-Coated Tantalum and Niobium, attached here as Exhibit B. Figure 1 of Exhibit B shows the increased hydrogen permeability for tantalum, vanadium and niobium at lower temperatures. Due to this relationship between the temperature and the hydrogen permeability, it would not have been obvious for one of ordinary skill in the art to utilize the flameless combustor process heater of Mikus et al. disclosed as useful for providing higher reaction temperatures, in a steam reforming reactor as disclosed in Minet et al. Therefore, the present invention would not have been obvious to one of ordinary skill in the art based on the prior art of Minet et al. and Mikus et al.

Claim 9 was rejected under 35 U.S.C. §103(a) as being unpatentable over Minet et al. in view of Mikus et al., as applied to claim 1, and further in view of Shirasaki et al. (US 5,639,431). Claim 9 has been cancelled.

Claims 16, 18, 22 and 25-28 were rejected under 35 U.S.C. §103(a) as being unpatentable over Minet et al. in view of Mikus et al., as applied to claim 1, 12 and 13, and further in view of Lin et al. (EP 1 024 111). Applicants respectfully traverse this rejection. Claims 16, 18, 22 and 25-28 are all dependent on claim 1, and are not obvious for the reasons discussed with respect to claim 1 above.

Claim 23 was rejected under 35 U.S.C. §103(a) as being unpatentable over Minet et al. in view of Mikus et al. and Lin et al., as applied to claims 1, 12 and 22, and further in view of Juda et al. (US 5,904,754) or Rosset (US 2,958,391) or Behr et al. (US 4,496,373). Applicants respectfully traverse this rejection. Claim 23 is dependent on claim 1, and is not obvious for the reasons discussed with respect to claim 1 above.

Claim 24 was rejected under 35 U.S.C. §103(a) as being unpatentable over Minet et al. in view of Mikus et al. as applied to claims 1 and 12, and further in view of Rosset. Applicants respectfully traverse this rejection. Claim 24 is dependent on claim 1, and is not obvious for the reasons discussed with respect to claim 1 above.

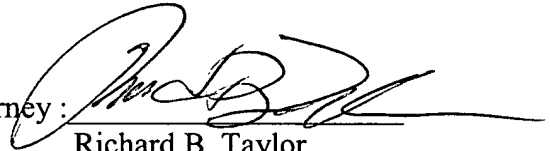
Claims 31-35 and 46 were rejected under 35 U.S.C. §103(a) as being unpatentable over Minet et al. in view of Mikus et al as applied to claim 1, and further in view of Topsoe (US 5,169,717). Applicants respectfully traverse this rejection. Claims 31-35 are all dependent on claim 1, and are not obvious for the reasons discussed with respect to claim 1 above. Claim 46 has been canceled.

In light of the above, Applicants respectfully request allowance of the pending claims in the application.

Respectfully Submitted,

WELLINGTON, Scott Lee et al.

By their attorney :

A handwritten signature in black ink, appearing to read 'Richard B. Taylor', written over a horizontal line.

Richard B. Taylor
Reg. No. 37,248
Shell Oil Company
(713) 241-3558